MERRA - NASA's Reanalysis Overview & Status

Michele Rienecker, Max Suarez, Ron Gelaro
Julio Bacmeister, Ricardo Todling, Larry Takacs, Emily Liu, Steven Pawson
Michael Bosilovich, Siegfried Schubert, Gi-Kong Kim
&
GMAO

http://gmao.gsfc.nasa.gov/merra

Presentation to Code 610

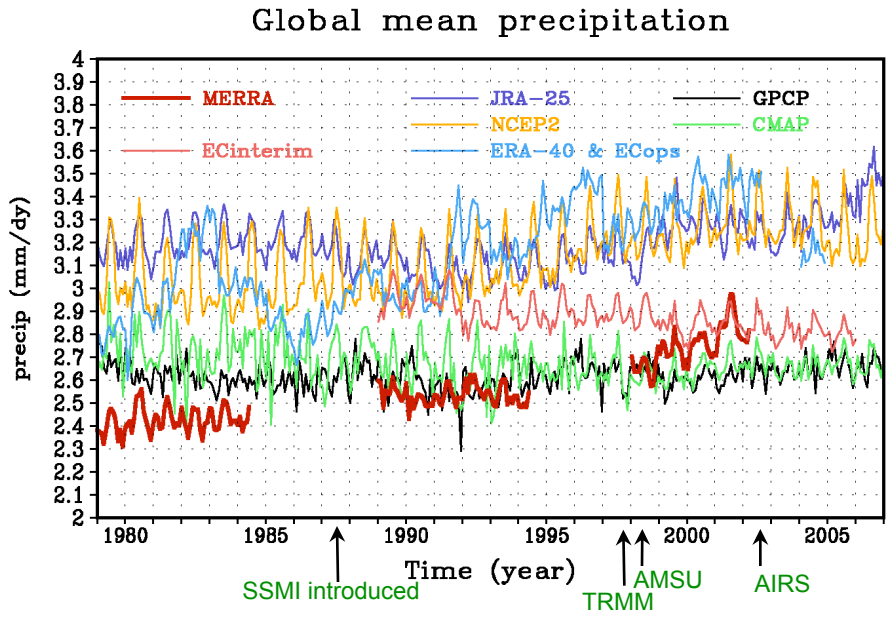
Jan 5, 2009

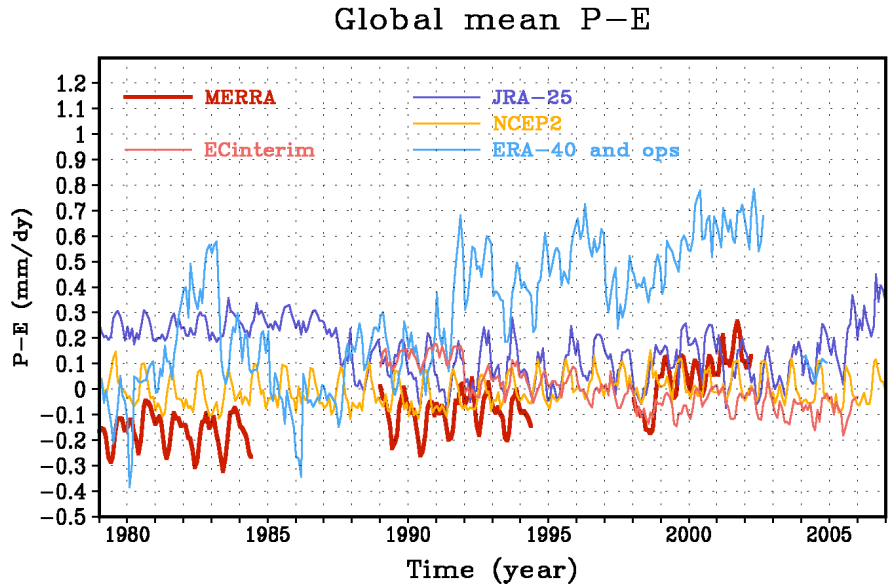
MERRA

The Modern Era Retrospective-analysis for Research and Applications is a reprocessing of atmospheric observations from 1979 to present using the GEOS-5 Data Assimilation System.

The focus of MERRA is the hydrological cycle.

Assimilation of the historical data stream: consistent Climate Data Records for several Essential Climate Variables concurrently.





GEOS-5 Atmospheric Data Assimilation System

AGCM

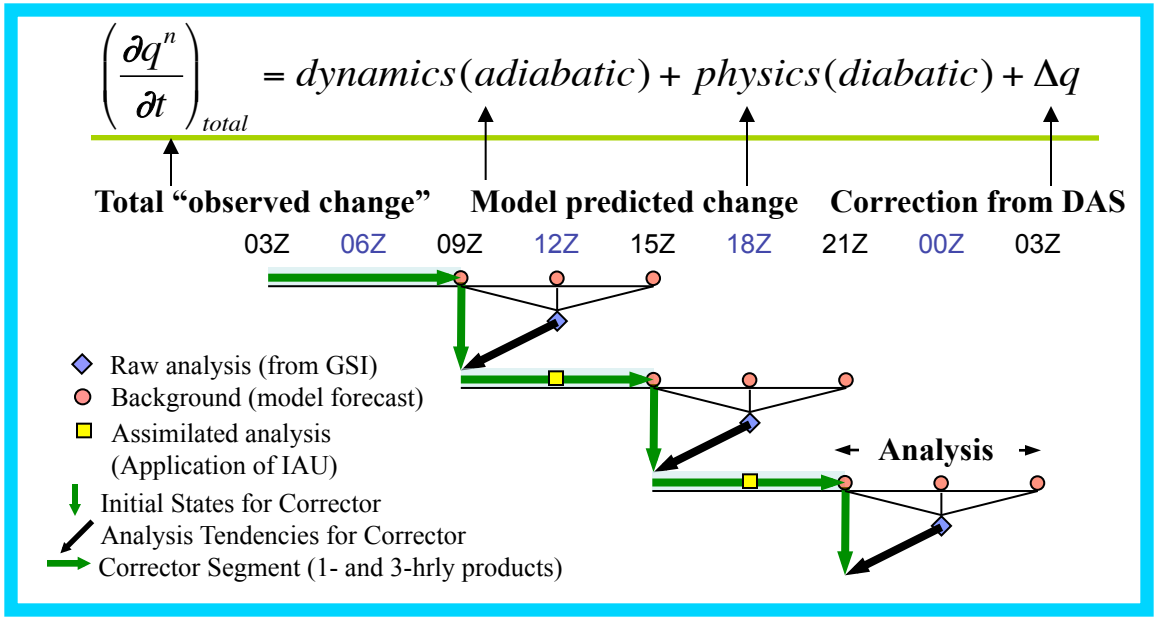
- Finite-volume dynamical core
- Integrated set of physics packages
- Physics integrated under the Earth System Modeling Framework (ESMF)
- Generalized vertical coord to 0.01 hPa
- Catchment land surface model
- Prescribed aerosols
- Interactive ozone
- Prescribed SST, sea-ice

Analysis

- Grid Point Statistical Interpolation (co-dev. with NCEP)
- Direct assimilation of satellite radiance data using JCSDA Community Radiative Transfer Model (CRTM)
- Variational bias correction for radiances

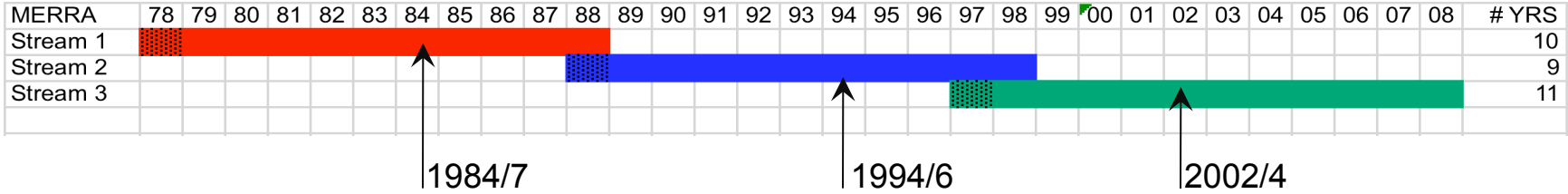
Assimilation

- Apply Incremental Analysis Increments (IAU) to reduce shock of data insertion
- IAU gradually forces the model integration throughout the 6 hour analysis period
- Provides a "replay" capability



MERRA Production

- 1979 – present
- 1/2° × 2/3° × 72L
- 2-year spin up at 2-degree resolution
- 1-year spin up at ½ degree
- Product Streams begin: Jan 1 – 1979, 1989 and 1998



- **Preview/Validation runs:**
  - Jan, Apr, Jul, Oct 2004
  - July-August 1987
  - Jan, Jul 2001
  - Jul 2006

- **2 degree (scout) runs** ⇒ preliminary look at data and spin-up of satellite bias estimates.

Validation Foci:

- Climate (comparisons with NCEP R1&R2, ERA-40, EC-Ops, JRA-25, CERES/ERBE TOA fluxes, GPCP precipitation, ..)
- Comparisons with satellite observations (CloudSAT, TRMM, SSMI, …)
- Hydrological cycle (comparisons with GPCP, CEOP, …)
- Land surface hydrology and energy balances
- Climate variability: Diurnal cycle, monsoons, …
- Stratosphere, constituent transport, QBO
- Marine surface fluxes
- Budgets

Note: little attention to NWP skill scores in system tuning

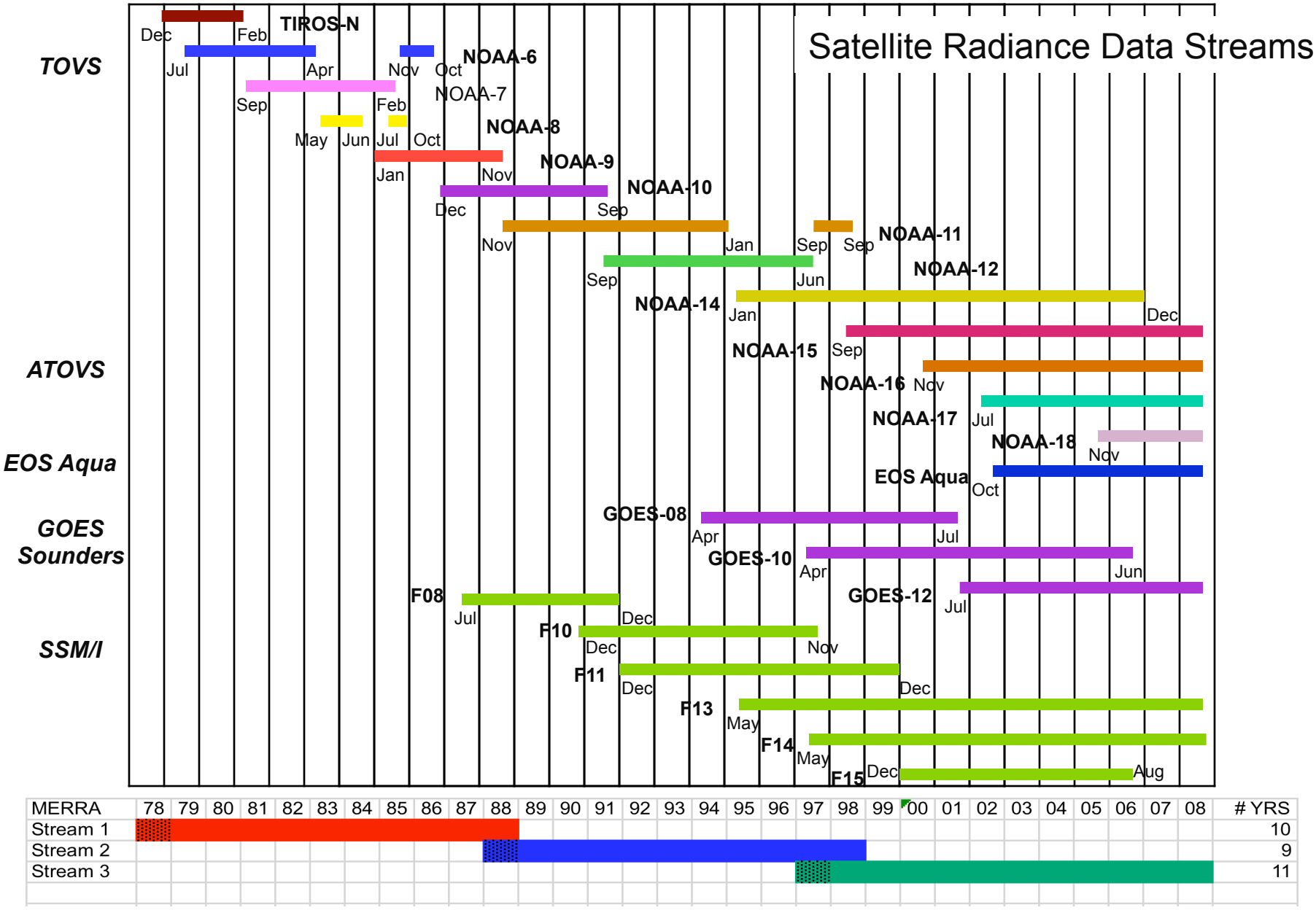
MERRA External User Group

Phillip A. Arkin	ESSIC, UMD	Moderator
Alan K. Betts	AER	Land, Planetary Boundary Layer
Robert X. Black	Georgia Inst. Tech.	Synoptic Dynamics
David H. Bromwich	Byrd Polar Research Ctr.	Arctic
Jose Rodriguez	GSFC	Atmospheric chemistry
Steven W. Running	U. Montana	Land Biophysics
Paul W. Stackhouse, Jr.	LaRC	Surface Radiation Budget, Applications
Kevin E. Trenberth	NCAR	Climate
Glenn H. White	NOAA/NCEP	Ocean Flux, Reanalysis
John Roads	SIO	Regional energy budgets

GMAO POCs

Scientific issues, scripts, etc: Michael Bosilovich, 4-6147, Michael.Bosilovich@nasa.gov

Data access: Gi-Kong Kim, 4-5355, Gi-Kong.Kim-1@nasa.gov


Satellite Radiance Data Streams
TOVS
ATOVS
EOS Aqua
GOES Sounders
SSM/I
TIROS-N
Dec
Feb
NOAA-6
Jul
Apr
Nov
Oct
NOAA-7
Sep
Feb
May
Jun
Jul
Oct
NOAA-8
Jan
NOAA-9
Nov
Dec
NOAA-10
Sep
Nov
Jan
Sep
Sep
NOAA-11
Sep
Jun
NOAA-12
NOAA-14
Jan
Dec
NOAA-15
Sep
NOAA-16
Nov
NOAA-17
Jul
NOAA-18
Nov
EOS Aqua
Oct
GOES-08
Apr
Jul
GOES-10
Apr
Jun
GOES-12
Jul
F08
Jul
Dec
F10
Dec
Nov
F11
Dec
Dec
F13
May
F14
May
F15
Dec
Aug
MERRA
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08
YRS
Stream 1
10
Stream 2
9
Stream 3
11

MERRA FILE COLLECTIONS

• Distributed through a modeling data portal at the Goddard DISC:
http://disc.sci.gsfc.nasa.gov/MDISC/

• MERRA products are organized into 24 collections in HDF
• All distributed data products have slightly degraded precision and are compressed with gzip.

• Data are produced on three horizontal grids:
  • Native ---------- (1/2 by 2/3 w/ FV conventions)
  • Reduced ------- (1½ by 1½ Dateline-edge, Pole-edge)
  • Reduced FV -- (1 by 1¼ w/ FV conventions)

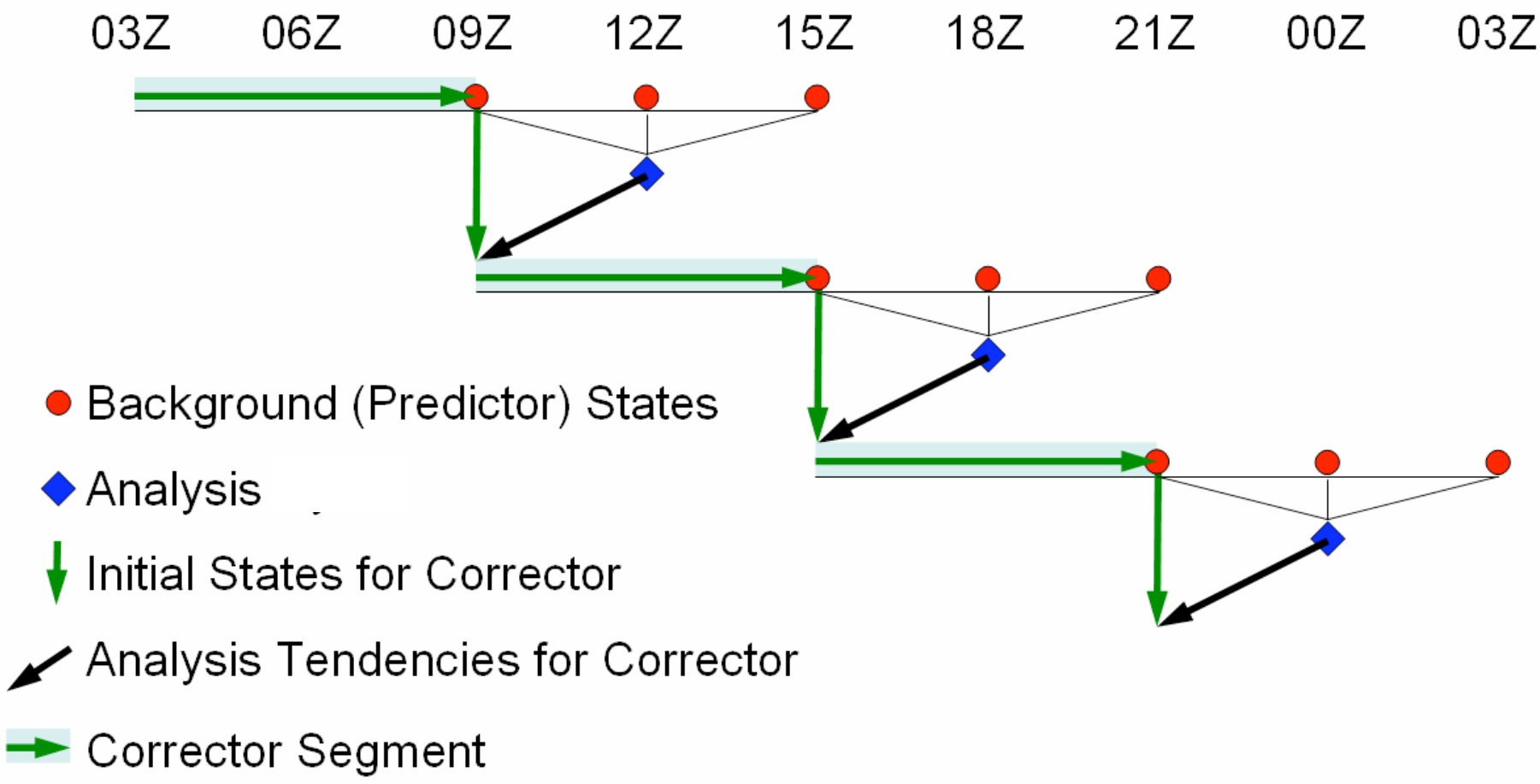
• In the vertical, 3-D data are on:
  • 72 model layers
  • 42 pressure levels

• Diagnostics temporal resolution:
  • 3D products are 3-hourly
  • 2D products are hourly

• Total online collections ~70TB

http://gmao.gsfc.nasa.gov/research/merra/MERRA_FileSpec_DRAFT_09_02_2008.pdf

MERRA products are from both *Analysis* and *Assimilation*



MERRA FILE COLLECTIONS

ANALYZED FIELDS (u,v,t,q,O_3,p) [2]
NATIVE, INSTANTANEOUS, 6-HOURLY
MODEL AND PRESSURE LEVELS

INVARIANTS [2]

ASSIMILATED FIELDS [1]
REDUCED, INSTANTANEOUS, 3-HOURLY
PRESSURE LEVELS

3-D DIAGNOSTIC FIELDS [8]
REDUCED, TIME-AVERAGED, 3-HOURLY
PRESSURE LEVELS

2-D DIAGNOSTIC FIELDS [5]
NATIVE, TIME-AVERAGED, HOURLY

PRODUCTS FOR OFFLINE
CHEMISTRY TRANSPORTMODELS [6]
VARIOUS RESOLUTIONS FREQUENCIES AND GRIDS

Summary

- Results from validation runs:
  - GEOS-5 analysis improves upon many features of existing reanalyses
  - Biases generally smaller than climate signals
  - Precipitation issues remain: trends; diurnal cycle
- Comprehensive output suite
- Expect to complete processing to end of 2007 by August 2009

ACKNOWLEDGMENTS

- NCEP, NESDIS – for GSI and CRTM for historical data streams
- Peter Colarco (with Arlindo da Silva) for aerosol distributions
- Code 613.3 for SBUV, V8
- NCCS for tremendous support for production queues
- SIVO for help with performance issues
- GES DISC for the MDISC and support in online product distribution
- External User Group for evaluation of early products and guidance on products
- Don Anderson & Tsengdar Lee for programmatic and moral support

And next…..

- The hydrological cycle - Michael Bosilovich
- Climate validation of MERRA - Siegfried Schubert
- The stratospheric analysis and chemistry transport - Steven Pawson
- Accessing MERRA online - Michael Bosilovich
- Questions??